UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 688 SEPTEMBER 18, 1915

Contribution from the Bureau of Plant Industry, Wm. A. Taylor, Chief.

THE CULTURE OF RICE IN CALIFORNIA.

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CONTENTS.

INTRODUCTION.

The Office of Cereal Investigations of the Department of Agriculture inaugurated variety tests of rices in the vicinity of Biggs, Cal., in the spring of 1909. These tests were continued in this locality during the season of 1910–11, and during the same period similar tests were made of a smaller number of varieties at several places in the Sacramento and San Joaquin Valleys. These plantings furnished some valuable data on the commercial possibilities of rice culture in California and were largely responsible for the beginning of the industry.

These results were obtained in cooperation with ranchers, but in order that these studies might be enlarged and conducted under conditions more favorable for experimental work, the Biggs Rice Field

NOTE.—This bulletin will be of interest to the rice growers of California.

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Station (fig. 1) was established in 1912 through cooperation with the Sacramento Valley Grain Association, an organization composed of ranchers. The station farm, consisting of 57 acres, is located 4 miles northwest of Biggs and is irrigated by gravity from the Feather River through a canal system operated by the Sutter-Butte Canal Co. Its soil is black adobe, which is representative of a considerable acreage of land in the Sacramento Valley upon which rice has been produced commercially for the last three years.

The first commercial crop of rice in California was grown in 1912 on adobe soil in the Sacramento Valley near Biggs. The profits from this crop of 1,400 acres were large. The wide publicity that was given to the possibilities of rice culture on this adobe soil resulted in the sowing of 6,000 acres in 1913. The greater part of this acreage was in Butte County, though there were several small plant-

FIG. 1.—Buildings at the Biggs Rice Field Station.

ings in the San Joaquin Valley. The average yield of 3,200 pounds of grain per acre which was produced by the 1913 crop gave so great an impetus to the industry that in 1914 the area sown in rice was increased to 16,000 acres, adding over $800,000 to the agricultural wealth of the State.

The recommendations in this bulletin are based upon the results obtained at the Biggs Rice Field Station and a study of the conditions under which rice has been grown in California.

GENERAL REQUIREMENTS OF THE CROP.

Irrigation is an important feature in the culture of rice. Water must be applied continuously and at a uniform depth for many days. To meet these requirements the land which is selected for this crop should be level and underlain by a subsoil that is impervious to water. It is less expensive to prepare a level tract for irrigation than a rolling one, and the cost of maintenance is also less, because there are fewer levees. The impervious stratum of soil should lie near the surface, for a deep soil requires more water and more time for its submergence than a shallow one.

Good drainage is necessary to get the land in condition quickly for harvesting and to prevent water-logging, a condition which unquestionably affects the yield. Clay soils, when easily drained and not too deficient in organic matter seem well suited to the production of rice. Loamy and even sandy soils produce good crops of rice under ideal conditions of irrigation and drainage.

AREA WHERE RICE IS GROWN.

The rice acreage in California in 1914 was distributed by counties as follows (fig. 2): Butte, 11,750; Colusa, 3,000; Glenn, 120; Yuba, 600; Yolo, 80; Placer, 120; Merced, 150; King, 80; Kern, 100.

The production of rice in 1914 was confined to the Sacramento and San Joaquin valleys, the northern and southern sections of a continuous valley of more than 400 miles in length and from 20 to 60 miles in width that occupies the north-central portion of the State. To the east of this great valley lie the foothills and the forested slopes of the Sierra Nevada Mountains. Many perennial streams flow into the valley from this region of heavy precipitation. The western wall of this valley is formed by the Coast Range. No perennial streams having their source in these mountains reach the floor of the valley.

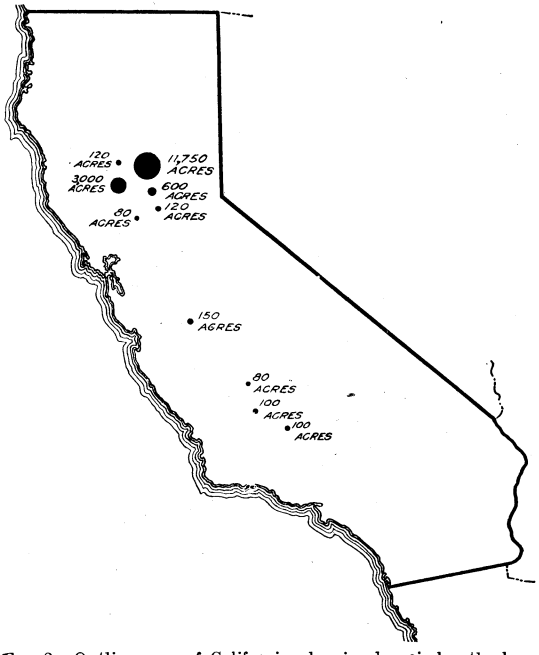

FIG. 2.—Outline map of California, showing by circles the location and acreage planted to rice in 1914.

CLIMATE.

The prevailing climatic conditions of this great central valley are moderate rainfall, hot summers, mild winters, low humidity, and light wind movement. The region is semiarid. It seldom rains during the summer months, the rains occurring usually from October to May. These limits, however, are subject to considerable variation. The average annual rainfall ranges from 24 inches at Red Bluff to 5 inches at Bakersfield.

The mean annual temperature ranges from 60° to 65° F. The highest temperatures occur in the months of July and August, ranging from 105° to 115° F. During the hot months there is often a daily variation of 40°, resulting in rather cool nights. In the winter minimum temperatures of less than 25° F. are seldom recorded. The usual minimum is about 28° F. Frosts frequently occur in December and January.

In the Sacramento Valley the prevailing wind during the spring and autumn months is often brisk. Hot, dry winds from the north sometimes occur during the hot summer months. In their extreme form they are known as "northers." When they continue for several days they often do considerable damage to rice, especially if they occur while the crop is in flower.

SOILS.

The larger part of the rice crop in California is on black adobe soil. This soil contains approximately 50 per cent of clay. In structure it is very close and compact. It is exceedingly tenacious and puttylike when wet. During the dry season it breaks at the surface into blocks separated by deep cracks. After long exposure to the air these blocks divide and subdivide by smaller cracks until the surface of the soil may become a loose, shallow mass of small pieces the size of peas. The subsoil, which lies at a depth of approximately 3 feet, is gray in color and is rather impervious to water. There are approximately 200,000 acres of this soil in the Sacramento Valley that may be used for the culture of rice.

The Sacramento silt loam, a light-brown soil which occupies a large area in the eastern part of Colusa County, seems well adapted to rice. It is of alluvial origin and varies in depth from 18 inches to 6 feet. In texture and structure it is variable, but, as a rule, it can be easily cultivated. The heavier type of this soil has a tendency to form hard clods, which are somewhat difficult to reduce.

Average yields of rice have been obtained on the Willows clay. This is an indefinite type of soil that occurs in large areas on the nearly level plains south and southeast of Willows. It has a depth of approximately 6 feet. This soil is of a reddish and yellowish brown clay that is compact, tenacious, and impervious. It puddles badly when wet and bakes upon exposure to the sun. On account of its texture this soil is not easy to cultivate. It contains from 0.04 to 1.2 per cent of alkali.

Rice has been successfully grown on the Alamo clay-loam adobe. This soil varies in color from dark gray to black and in depth from 1 to 5 feet. It is both sedimentary and alluvial in formation and lies upon a red hardpan. It occupies an area that is subject to overflow during the rainy season.

Other types of clay soils in these two valleys have been used for rice with success. Average yields have been obtained on some where the surface of the soil gave indications of a high alkali content. These salts may be present in a relatively small quantity near the immediate surface, and can therefore be easily removed by the irrigation water, which may indicate that with thorough drainage and an ample supply of water for irrigation rice may be profitably used to reclaim these alkali lands. Rice is apparently more resistant to alkali salts than other cereals.

Table I shows the yields and acreage of commercial rice in California in 1913 and 1914.

Late seeding and watering and barnyard grass are mainly responsible for the failures and low yields.

TABLE I.—*Yields and acreage of commercial rice in California in 1913 and 1914.*

Yield per acre.	1913		1914	
	Acres.	Per cent of total acreage.	Acres.	Per cent of total acreage.
5,500 to 7,000 pounds	80	1.3	600	3.8
4,500 to 5,500 pounds	720	11.7	2,250	14.1
3,500 to 4,500 pounds	2,300	37.0	3,525	22.0
2,500 to 3,500 pounds	1,250	20.2	4,375	27.3
1,500 to 2,500 pounds	800	12.9	2,750	17.2
500 to 1,500 pounds			750	4.7
Harvested, but not thrashed	250	4.0		
Not harvested	800	12.9	1,750	10.9
Total	6,200	100	16,000	100

PREPARATION OF THE SEED BED.

When not contrary to good farm management, and when the nature of the soil will permit, plowing should be done in the late autumn. There should be good drainage, so that the winter rains may wash out the alkali which may have accumulated in the surface soil. Deep plowing should be practiced. The action of the water during this period will have the effect of reducing the clods, which will lessen the amount of disking and harrowing necessary for preparing a good seed bed the following spring.

If plowing is postponed until spring, the land should not be left in furrows, but should be disked and harrowed at once and not allowed to dry out before sowing. The vigorous growth of the young plants, as well as high germination, is dependent upon how well the soil has been prepared for seeding.

PREPARATION OF THE SEED.

The seed should not be sown until it has been carefully fanned and screened. The fanning mill is usually used for this work. It grades the seed and removes the light grains, trash, and most of the weed

seeds. A poor stand and reduced yields are generally obtained when ungraded seed is sown. The use of cleaned seed is one method by which weeds may be controlled in a rice field.

Unless the crop is properly shocked, the germinating power of the seed may be greatly injured during a wet harvest. A germination test should always be made of seed that has been exposed to unfavorable conditions. At least three lots of 100 grains each should be taken for this test from a composite sample of the seed to be sown. Each lot should be placed separately between blotters or Canton flannel, which must be kept moist and at a temperature of approximately 70° F. Within a week each lot should be examined and the number of seeds with strong sprouts counted.

It is more economical not to sow seed of low vitality, but, if used, the rate of seeding per acre should be higher than that commonly recommended for the variety.

MANNER OF SEEDING.

In sowing rice, the seed should be distributed evenly and covered uniformly. These results are more easily obtained by drilling the seed than by broadcasting it. When drilled, less seed is required and, as a rule, a more uniform stand is secured. Any one of the ordinary forms of drill may be used if the seed bed is in good tilth.

DEPTH OF SEEDING.

Rice should be sown under ordinary conditions at a depth not exceeding 2 inches, but a greater depth may be required on a cloddy field, in order to cover the seed well. With proper moisture conditions a less depth is desirable on a well-prepared seed bed. If irrigation is necessary to germinate the seed, and in most cases it will be, the seeding should not be too shallow, or the water may float and scatter the seed.

RATE OF SEEDING.

The quantity of seed that should be sown will vary with the variety of rice, the vitality of the seed, the fertility of the soil, the character of the seed bed, and the method of seeding. Under ordinary conditions on black adobe soil 90 pounds of seed to the acre are sufficient for the Wataribune variety. The long-grain varieties, which usually do not tiller as freely as the short-grain ones (of which Wataribune is a type), should be sown in excess of the rate recommended for the latter.

Thin seeding may induce excessive tillering, which will invariably result in irregular ripening and low yields. On a good seed bed less seed will be required than will be necessary to secure an average stand on a poorly prepared one. If weedy land is used, the rate of seeding should be greatly increased. It is always necessary to use more seed in broadcasting than in drilling.

TIME OF SEEDING.

In California it requires approximately six months to mature a crop of Wataribune rice. Until other varieties can be obtained that will mature in less time, early planting should be practiced. The crop should be planted so that it may be harvested before the autumnal rains begin. If planted at an early date, the crop will flower under normal conditions during the period of high temperatures, with a resulting increase in yield and improvement in quality. The risk of losses from wet weather increases as the harvest period becomes later. In a date-of-seeding test at the Biggs Rice Field Station, in which rice was sown every 15 days from April 1 to May 15, inclusive, the early seeding invariably gave the largest yields. The yields decreased from 400 to 500 pounds per acre with each successive later planting. The same proportional decrease was noted on the commercial plantings in the vicinity of Biggs. April 1 is recommended as the approximate date for sowing rice in California. It is never safe to seed Wataribune rice after May 1.

IRRIGATION.

The water that is used for the irrigation of rice in the Sacramento Valley is obtained by gravity, mainly from the Sacramento and Feather Rivers. In the San Joaquin Valley the water is supplied by small streams and deep and flowing wells.

Because continuous submergence at a uniform depth is necessary for the growth of rice, only level land with a good slope for drainage should be selected for this crop. The field should be inclosed by strong embankments and so subdivided that each subfield shall have a surface level enough to hold the irrigation water at the required depth.

These conditions can be obtained by constructing field levees on contour lines at distances which, during submergence, will hold water at an average depth of 5 or 6 inches. These levees should be just high enough to prevent the water from overflowing into the subfields below and so broad that all kinds of machinery used in the cultivation of rice may pass over them easily without damaging them. Such levees will be low and very broad. They should be planted to rice. If this is done the cultivated area is increased and no uncultivated strips of land are left in the field for the growth of weeds. The growth of rice upon the field levees may not be equal in every respect to the main crop, but the results that will be obtained in the control of weeds alone will justify the practice.

The levees should be permanent and accurately located. For this work a competent civil engineer should be employed. The location of contour lines, the construction of levees, and the leveling should

cost about $9 per acre for permanent wide levees and approximately $2.60 for temporary levees.

The successful growth of this crop often depends upon the availability of water at the time of planting. While it may not always be necessary to apply water for the germination of the seed, it is never safe in this section to seed the crop without having a good supply of available water.

If the water supply is to be developed from wells, the digging of the wells should precede the planting. Where this has not been done, heavy losses have resulted. The acreage to be watered from a well should never overtax the supply. Until more is known about the underground waters of these two valleys, wells should not be depended upon as the only source of water for rice, except in the artesian districts.

On typical adobe soil, and probably on all of the clay soils upon which rice may be grown, it may be necessary to apply water to germinate the seed. A seed bed on these soils loses its moisture very quickly. Under normal weather conditions a good seed bed on soils of lighter texture may not require the application of water for germination. Such soils, if well drained, would probably permit very early planting, which, in California, will always be an advantage.

Great care should be taken in irrigating to obtain germination. Soil and atmospheric temperatures are usually low at this season of the year, and if the water is left on the land too long the seed is likely to rot. Before the plants come up, water should not be allowed to remain on the land longer than 24 to 48 hours after each irrigation. After planting, the soil should never be allowed to dry out. This will require frequent irrigation, and a supply of water should always be available and abundant enough to meet general requirements.

Tests at the Biggs Rice Field Station indicate that the land should be submerged for approximately 30 days after the plants have come up and that the best depth of water is from 5 to 6 inches. This depth should be maintained until the heads (botanically called panicles) are well turned down, when the fields should be rapidly drained.

Paying crops of rice can not be produced without submerging the land continuously for a period of several months. The growing of rice on soil that is merely kept moist and not submerged should not be considered seriously.

The amount of water required to make a good crop of rice will depend largely upon how well the outside levees have been constructed and what quantity of water is allowed to flow through the field. Poorly constructed outside levees are responsible for the loss of much water by seepage. The loss is further increased by allowing too

much water to flow through the fields in an effort to keep the field water fresh.

The levees that inclose the field should be firm and compact. If they are next to a field that is not under irrigation, they should be very broad. Seepage is greater through levees that are constructed of black adobe soil than through levees that are made of other types of clay.

After a field has been submerged, no more water should be admitted than is needed to maintain the required depth. This will be rather small if there is no loss through seepage. The overflow of water should be no more than a mere film. From many fields it is often several inches. This is an extravagant use of water and should not be practiced. The field water will not become stagnant if freshened only once in 10 days.

Too much attention can not be given to levees and to the delivery and discharge of water. Payment for water should be based upon the volume delivered. Upon this basis it would be more economically used, other conditions being equal, than could reasonably be expected when sold on a flat charge per acre.

On commercial fields of rice where the water was accurately measured during the last season in cooperation with the office of irrigation investigations of this department, the amount used on adobe soil in the vicinity of Biggs varied from 4.65 to 8 acre-feet. This range is too great, but more data must be obtained before definite statements can be made regarding the quantity of water that may be necessary to produce a crop of rice under California conditions.

One 40-acre field which produced a yield of 6,000 pounds of grain per acre received 4.65 acre-feet of water. This field had well-constructed levees and was carefully watered. The other fields did not have the levees so well constructed and were not so carefully watered. It is safe to conclude that faulty levees cause the loss of much water and that a waste of water can be prevented by giving daily attention to the manner of its application.

DRAINAGE.

A field of ripe rice should be rapidly drained. This is very necessary in order to harvest the crop at the least expense of time and labor and to prevent the loss of grain. Even with increased power a self-binder can not do efficient work on wet ground. Boggy fields will delay harvesting, and this delay will invariably result in reduced yields from the shattering of the grain.

It is just as important to provide means for the removal of irrigation water from a field of ripe rice as it is to provide means for supplying water to the growing crop. This is not appreciated as it

should be. There are difficulties, it is true, but these can be overcome. It is an engineering problem, requiring community cooperation, and can be readily solved by the creation of drainage districts.

The natural drainage facilities of the level land upon which rice is grown are always overtaxed. It is often the case that little or no field drainage can be had until outlets have been made, and the success of these depends upon their connections with watercourses of sufficient capacity. Poor drainage, or the lack of drainage, results in underproduction through the waterlogging of the land and the accumulation in the surface soil of harmful salts, commonly called alkali.

After their construction, drainage ditches need constant attention. They must be kept free from all kinds of obstructions, especially weeds, which grow luxuriantly in them, or their efficiency will soon become greatly impaired.

It should be remembered that a well-aerated soil is just as essential for rice as for any other crop, if maximum yields are to be maintained.

HARVESTING THE CROP.

Rice should be cut promptly when ripe. If exposed too long to the sun the ripe grains are likely to become cracked. Cracked grains will break when milled, and as the price of rough rice is based largely upon a crude test to determine the percentage of head rice, or whole grains, it is important that great care should be taken in cutting, shocking, and thrashing, in order to reduce breakage. In the cleaned-rice market the highest price is always paid for head rice, and as a result the miller makes his highest bid on the rough rice which, in his opinion, will produce large yields of this grade.

A twine binder should be used in cutting the crop, which is ready to harvest when the kernels on the lower part of the head are not entirely hardened. At this stage of maturity the heads are well turned down. If cut earlier, a large percentage of the kernels will be imperfectly formed. If cut later, the loss from shattering is likely to be heavy, for rice shatters badly when left standing until fully ripe.

The milling quality of rice is further increased by prompt and careful shocking. As soon as the grain is cut the sheaves should be put in round shocks. These shocks should be strongly built to withstand the wind and well capped to protect the grain from rain and sun.

In building a shock (fig. 3) the first two bundles should have the butts firmly set into the stubble and sufficiently apart to be well braced when the heads are brought together. About these set up from 8 to 10 bundles in such a manner as to form a round shock, making provision at the same time for free circulation of the air. Select a large bundle to serve as a cap. Slip its band down to the heads and put it in an upright position with the heads down and in contact with the heads of the bundles forming the shock. When it is in this posi-

tion open the bundle from the center by bending the straw at the band. Pull down the straw and spread it evenly to make a covering for the heads of the cap bundle and the underlying bundles. The grain is not exposed in such a shock and is well protected from rain and sun.

The size of the shock will depend upon the degree of ripeness and the length of the straw. Small shocks should be used when the straw

FIG. 3.—A field of harvested rice in the Sacramento Valley.

is short or not entirely ripe. During dry weather the process of curing requires at least two weeks. When the crop is weedy and the weather rainy this period is considerably prolonged.

THRASHING.

Rice should not be thrashed until the kernel is hard and the straw thoroughly dry. It will dry much better in a well-constructed shock,

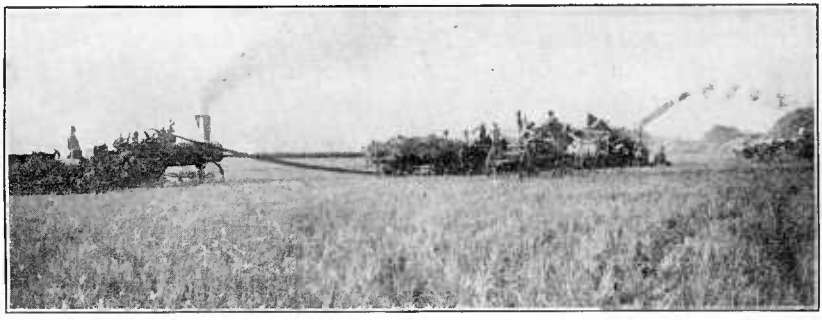

FIG. 4.—Thrashing rice in the Sacramento Valley.

even though exposed to heavy rains, than it will after it is stored. Good thrashing can not be done when the straw is tough, and if the grain is stored while damp it is likely to heat and mold. Moldy rice never commands a good price.

As a protection against the introduction of weeds from a neighboring farm and against the mixing of varieties, the thrashing machine

(fig. 4) should be thoroughly cleaned before using. The hulling and cracking of the grains can be prevented by a careful adjustment of the concaves.

COST OF RICE PRODUCTION.

The cost of production per acre given in Table II is computed on a yield of 3,500 pounds of grain per acre, which will increase or decrease in proportion to the yield at the rate of approximately 40 cents per 100 pounds. Although the land will be checked, the cost of production in the second year will probably be as great as in the first year because of the increased cost of plowing, preparation of the seed bed, and weeding. These figures apply to the adobe soil near Biggs, which is expensive to work. On soil of lighter texture the cost may be less.

TABLE II.—*Estimated cost of growing an acre of rice on adobe soil in the Sacramento Valley, Cal.*

Operation.	Cost per acre.	Operation.	Cost per acre.
Plowing	$3.00	Shocking	$1.00
Preparation of seed bed	1.25	Thrashing	7.00
Checking	2.60	Sacks and sewing twine	3.50
Drilling	.75	Hauling grain to warehouse	1.75
Boxes	.50	Water tax	5.00
Seed rice	2.00	Keeping field free from water grass	1.25
Care of crop, April to September, inclusive	4.00	Total	36.25
Twine	.40		
Harvesting	2.25		

VARIETIES.

Table III contains the names of the principal rices of the United States. The Honduras variety is extensively grown in Louisiana, Texas, and Arkansas. The Carolina Gold and Carolina White varieties are cultivated exclusively in the South Atlantic States. These three are long-grain rices and are highly valued by our domestic trade. In California they have been grown only experimentally and may never become a part of the crop, on account of their late maturity and comparatively small yields.

TABLE III.—*Period of growth and yield of the principal varieties of rice tested in the Sacramento Valley on black adobe soil.*

Name.	Date planted.		Date land was submerged.		Date of maturity.		Days to maturity.		Height of plant, including head.		Yield per acre.[1]	
	1913	1914	1913	1914	1913	1914	1913	1914	1913	1914	1913	1914
									In.	*In.*	*Lbs.*	*Lbs.*
Wataribune	Apr. 15	Apr. 6	June 5	June 6	Oct. 6	Oct. 25	174	202	41	33	5,350	7,020
Omachi	...do...	...do...	...do...	...do...	Oct. 10	Oct. 26	178	203	38	37	5,250	6,730
Shinriki	...do...	...do...	...do...	...do...	...do...	Nov. 1	178	209	34	30	5,420	6,730
Honduras	...do...	Apr. 5	...do...	...do...	Oct. 21	Nov. 5	189	214	48	49	3,240	2,930
Carolina White	...do...	...do...	...do...	...do...	Oct. 20	Nov. 3	188	212	48	43	3,600	3,850
Carolina Gold	...do...	...do...	...do...	...do...	Oct. 19	...do...	187	212	49	47	4,300	3,100

[1] Estimated upon the actual yields from one-tenth-acre plats.

The greater part of the acreage of rice in California has been planted to the Wataribune variety (fig. 5), a short-grain rice. It is late in maturing, but produces profitable yields of rough and head rice, which makes it very popular with both the rancher and the miller. It will probably continue to be the leading commercial variety until earlier high-yielding rices are obtained.

The acreage of the Shinriki variety is not likely to be increased, because of its short straw, small grain, and long period of growth, although it produces yields approximately as large as those of the Wataribune. Another short-grain rice, known as Spagnuolo, has

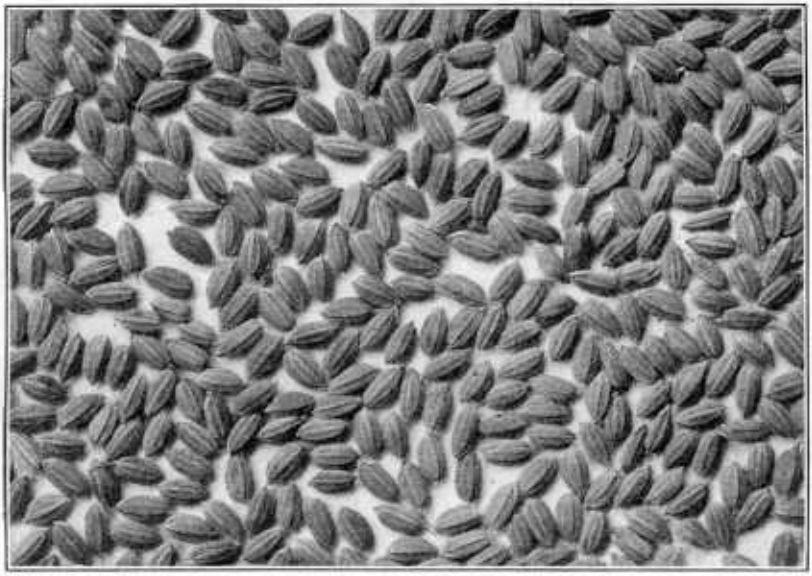

FIG. 5.—A commercial sample of seed rice of the Wataribune variety, which has been well thrashed and fanned. (Natural size.)

been grown on several ranches in the Sacramento Valley. It matures from three to four weeks earlier than the Wataribune and Shinriki, but shatters very badly and requires prompt harvesting. The Omachi variety has a grain very similar to the Wataribune, though slightly larger, and it may become as popular as the latter when grown commercially.

Earlier maturing varieties of good quality that will produce high yields are needed to prevent losses from high humidity and rain, which increase as the harvest period is delayed. Rices that ripen during September would not be exposed to rain at maturity under normal weather conditions and consequently could be harvested more cheaply and with less loss than could be done after the rainy season begins. Among the rices which are being tested at the Biggs

Rice Field Station are several which mature in September and are very promising in quality and yield. These are being increased for distribution.

IMPROVEMENT OF THE CROP.

Stand and yield can be greatly improved by using large, well-developed seed. Such seed can be mechanically selected by using a fanning mill or some other method for cleaning and grading.

The adaptability of a variety of rice to the region in which it is to be grown should always be carefully considered. Quality and productiveness can not be obtained from a variety when it is grown under conditions that are not favorable to its best development. A large sowing of a new variety should never be made until these characters are determined. It should first be tested in comparison with the leading local variety by making small plantings of it. If it is earlier than the variety that is usually planted and is equal or better in quality and yield, it may be sown for the general crop. Home-grown seed, however, if carefully selected and well graded, generally yields better than seed of the same variety from a distant locality.

In the Sacramento Valley earliness is desirable, in order to get the maximum benefit of the high temperatures at the time of flowering and to escape the autumnal rains. It can be developed by continued selection. The selections should be made at the time of ripening and from plants that are growing under ordinary field conditions if they are otherwise suitable. Plants growing near ditches or on or near levees should not be used.

The earliest and best heads should be selected and thrashed by themselves, preferably by hand. The seed obtained from them should be sown apart from the main crop on what may be termed a seed plat, the bed of which should be well prepared. When harvested, the crop from the seed plat should be thrashed by itself and the seed used the next year for planting the main crop. Before harvesting the seed plat, the best heads on it should be selected for use in planting the seed plat the following year. Permanent improvement of the rice crop can be obtained by continuing this practice year after year.

If the seed plat is not used, it may pay to get seed from the best parts of the field. These parts should be cut and thrashed separately from the main crop. The seed obtained in this way will not be superior seed, but may excel in quality the seed rice which is ordinarily sold, in that it is better adapted and probably freer from weeds and red rice. By repeating this year by year the rice grown on any farm will be appreciably improved.

A better method for improving the quality and yield of the rice crop would be to test and select strains which have been developed

from individual heads, but this work should be done by the agricultural experiment stations, as it requires more attention than the average farmer can give to it.

RICE PRODUCTS.

Rice leaves the thrasher with the hull or husk attached. It is called rough rice and in this condition is sold to the miller. In the mills it is prepared for the market. After the removal of the hull and cuticle the kernels are polished. This process improves the commercial value of the rice but decreases its food value.

After the rough rice has been cleaned, to remove all kinds of trash, it is conveyed to the milling stones, between which the hulls are removed. From these stones it passes over horizontal screens where the hulls and the whole and broken kernels are mechanically separated. The unbroken kernels are now conveyed to a set of machines known as hullers, in which the outer skin, or cuticle, and much of the gluten layer of the grain, together with the germ, are removed by friction. After leaving the hullers the rice is screened and fanned, to free it from the bran. It is now ready to be polished, a process which gives the grains the pearly luster that is demanded by the general trade. In the polishing process more of the gluten layer and many layers of starch cells are rubbed off. This product is called rice polish, or flour. From the polishing machine the rice passes to screens, where it is separated into different grades.

The unbroken kernels of milled or cleaned rice are known as head rice. This kind of rice always commands the highest price and is sold under several grades, which vary in the different markets but are separated largely upon the brilliancy of the polish and the color and size of the kernels. The broken kernels may be sold as ordinary or broken rice, screenings, or brewers' rice. The last grade is composed of very fine particles of the kernels.

The principal feeds that are obtained from rice are bran, meal, and polish. The bran is composed of the cuticle and the embryo with varying quantities of hulls. Bran that contains no hulls, or comparatively none, is called meal. It is the most nutritious of the rice feeds and when fresh is very palatable to domestic animals. On account of its high percentage of fat it often becomes rancid if kept too long. In polish, or rice flour, the percentage of fat and protein is much lower than in meal, while the percentage of starch is much higher. Polish is used for feeding cattle and pigs.

WEEDS.

Under the general term of weed may be included those plants that affect the full development and marketing of any crop. The plants that normally inhabit wet places find ideal conditions in a rice field

for rapid and luxuriant growth and if not eradicated when they first appear may cause heavy losses. As a rule, weeds produce a large number of seeds. On account of this and their general hardiness they are not easily controlled. Their presence in a field adds to the cost of production, reduces the yield, and produces an inferior grade of grain. A lower price is always offered for rice containing weed seeds.

The eradication of weeds is expensive, and it is therefore important to use every method to prevent their introduction. Most weeds are probably introduced into fields by sowing seed rice that has not been thoroughly cleaned. The irrigation water furnishes another source of infestation, being supplied from the weed growth in ditches and on ditch and canal levees. The community thrashing outfit also acts as a weed distributor. The danger from these sources can be greatly minimized by the exercise of care, cleanliness, and good judgment. Weeding by hand should be resorted to as soon as weeds appear in a field, unless their number is so great that the cost would make it prohibitive. In the latter case the land should be devoted to clean culture and occasionally irrigated to germinate the weed seed. No weed should be allowed to mature its seed. This applies to weeds on roads and levees as well as to weeds in the field. The former can be handled easily and cheaply by the use of mowing machines and scythes. The planting of field levees to rice will reduce the area for weed growth.

BARNYARD GRASS.

Barnyard grass (*Echinochloa crus-galli* (Linn.) Beauv.), which is locally known as water grass, is the worst weed to be found in the rice fields of California. It is a coarse, erect, or spreading annual, varying in height from 12 to 48 inches. It is widely distributed in all cultivated regions and grows luxuriantly in fields that are continuously irrigated. This weed produces a large number of seeds. On a single plant there may be as many as 40,000 seeds (fig. 6). It is therefore not safe to allow a single plant to go to seed in a rice field, for with such reproductive powers it would soon populate the field. During the past three years this grass has taken complete possession of more than 2,000 acres of rice land in the Sacramento Valley and is now present in alarming quantities on a considerable acreage, which will soon be rendered unprofitable for rice growing unless active steps are taken for its complete eradication or control.

This weed has probably been more widely distributed through the use of seed rice containing its seed than by any other means. Water from irrigation ditches upon whose banks it has been allowed to grow contributes its quota of seed. Occasionally the seed of this grass is carried from one field to another by the floods which sometimes occur during the winter.

Seed rice containing the seed of barnyard grass should not be used (fig. 7). As soon as this grass appears in a field it should be removed by hand before it goes to seed. Its seed usually germinates with the rice and in about two weeks after coming up it develops a more vigorous growth and a lighter green color than the rice plants. In 65 days after coming up it produces ripe seed, which, if allowed to germinate, will develop plants that will mature before the rice crop is harvested. None of these plants should be allowed to seed.

The only satisfactory method known at present for the eradication of this weed is to remove it from the field by hand work. On account of their large root systems it is not practicable to pull up the plants.

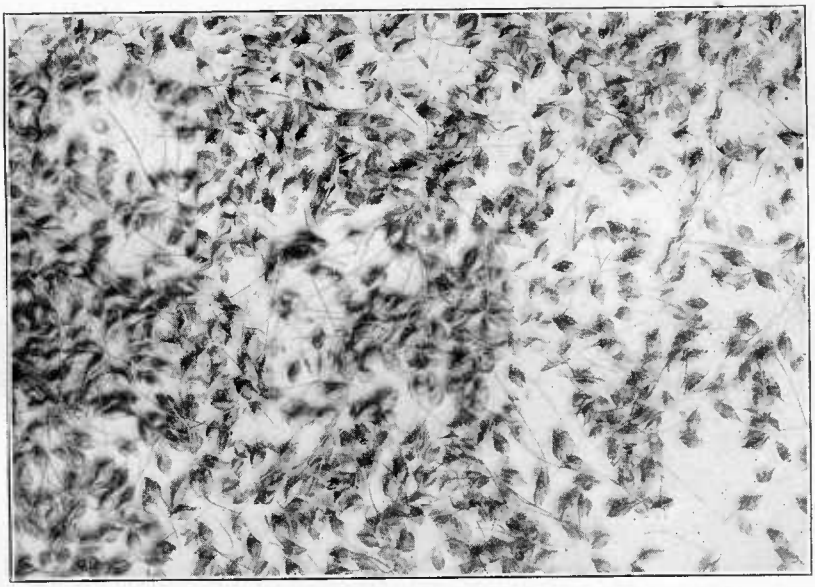

FIG. 6.—Seeds of barnyard grass. (Natural size.)

They should never be cut off at the surface of the ground, as is often done, for a new growth will develop and produce seed in about 40 days. The plants should be cut below the crown, which is usually covered with 2 inches of soil. Plants which have been cut at the surface have been known to develop seed as many as four or five times during a season. As soon as they have been cut the plants should be removed from the field, for they will continue to grow if they are allowed to remain in moist or wet places.

It has been found practicable and advisable to cut this grass from fields even when the growth is very heavy. The cost of eradication will depend largely upon the quantity in the field and upon the class and cost of the labor employed. The actual expense of cutting ranges from $2 to $5 and even more per acre. Several farmers have spent

with profit as much as $10 per acre to remove this grass from their fields. If this weed is allowed to seed in any quantity during the first year, it becomes very difficult and almost impossible to eradicate it during the second year.

A rotation of crops, including a cultivated one, and summer fallowing may be employed as the best means to obtain complete eradication of this weed. Conditions should first be made favorable for the germination of the seeds that are in the soil. After germination the plants should not be allowed to produce seed. This can be effectively done by frequent cultivation or by plowing the land as the

FIG. 7.—A commercial sample of seed rice of the Wataribune variety, containing many hulled grains and the seeds of barnyard grass. (Natural size.)

seed germinates. Irrigation will probably be necessary to assure germination.

In three seasons this weed has become a menace to the rice crop of the Sacramento Valley, and unless concerted action is taken for its control or eradication its presence may seriously affect the normal development of the rice industry of the State. This work may be effectively done through county or community organizations with police power.

RED RICE.

The worst weed of the rice fields of the United States is red rice. It has been introduced into California through the purchase of seed rice from the Southern States. Since imported seed may contain as much red rice as domestic seed there is also danger from this source.

This weed is well distributed throughout the rice-producing countries of the world. The seed coat of the kernel of this rice is red, a characteristic which may serve to distinguish it from the white rices. Wherever it is introduced, and this is possible only through the use of seed containing red rice, it soon takes possession of the field unless active measures are taken to eradicate it. In discussing seed rice from the standpoint of red rice only, the importance of pure seed can not be overestimated. After heading, red rice can be readily distinguished from our commercial varieties by its loose, open, slightly drooping head with comparatively few grains on the branches. A slight infestation of a small acreage may be easily controlled during the first year by pulling up the individual plants and removing them from the field. If this is not done, the quantity of red rice the second year will be greatly increased, for the seed of this rice shatters very badly. Of course some of it will be harvested and thrashed with the main crop, but the quantity will be proportionately small, though large enough to affect the grade. The presence of red rice always lowers the value of the crop.

WILD OATS.

The wild oat (*Avena fatua* L.) is not to be considered a serious weed in the rice field, though it often makes a vigorous growth in fields where the stand is thin. It is usually brought under control when the first continuous irrigation water is applied.

CANARY GRASS.

Canary grass (*Phalaris paradoxa* L.), which thrives in wet soil, has caused loss in some fields. It germinates with the rice and, as it grows much faster, it may seriously affect the early growth of the crop if it is very abundant. While canary grass may never become a troublesome weed, it should not be allowed to establish itself in a rice field. It should be removed by hand when it first appears.

SUMMARY.

Clay soil with an impervious subsoil, if it lies in level tracts and can be well drained, is well adapted to rice.

Shallow soils are preferable to deep soils, because less water will be required to submerge them.

Rice requires an abundant and always available supply of water.

April 1 is recommended as the approximate date for sowing rice in California. It is never safe to sow seed of the Wataribune, which is the leading commercial variety, after May 1.

On typical adobe, and probably on all of the clay soils on which rice may be grown, it may be necessary to apply water to germinate the seed. Great care should be taken in irrigating to obtain germina-

tion. Before the plants emerge, water should not be allowed to remain on the land longer than 24 to 48 hours after each irrigation. After planting, the soil should never be allowed to dry out. The water should be applied not less than 4 inches deep, and preferably from 5 to 6 inches, and should be applied approximately 30 days after emergence.

The field should be rapidly drained when the heads are well turned down.

The growing of rice on soil that is simply kept moist and not submerged is not to be seriously considered.

More data must be obtained before definite statements can be made regarding the quantity of water that may be necessary to produce a crop of rice under California conditions.

Field and outside levees should be permanent and accurately located.

Poor drainage, or the lack of drainage, results in underproduction through the waterlogging of the land and the accumulation in the surface soil of harmful salts, commonly called alkali.

Rice should be cut promptly when ripe. If exposed too long to the sun the ripe grains are likely to become cracked, which will cause heavy breakage in milling.

Early-maturing varieties of good quality that will produce high yields are needed to protect the crop from the probable losses through high humidity and rain, which increase as the harvest period is delayed.

Barnyard grass is the worst weed to be found in the rice fields of California. It has taken possession of more than 2,000 acres of rice land in the Sacramento Valley and is now present in alarming quantities on a considerable acreage, which will soon be rendered unprofitable for rice growing unless active steps are taken for its complete eradication or control. Seed rice containing the seed of barnyard grass should not be used. When present in a field in small quantity it should be removed by hand. A rotation of crops, including a cultivated one, and summer fallowing may be employed as the best means of obtaining the complete eradication of this weed.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1915